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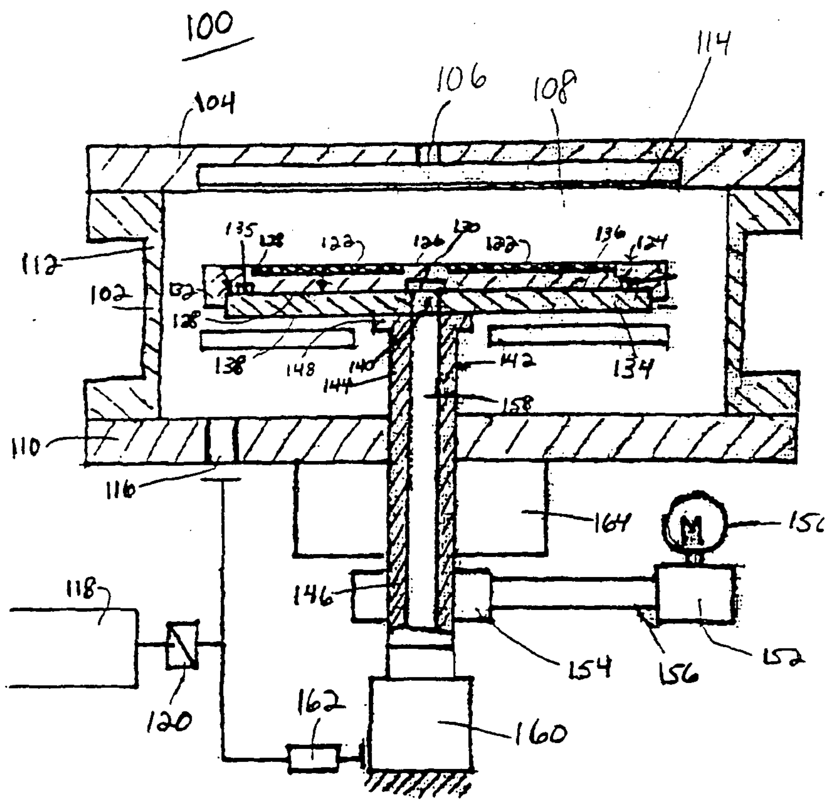
(54) Title: APPARATUS FOR GROWING EPITAXIAL LAYERS ON WAFERS



(57) Abstract: An apparatus for growing epitaxial layers includes a spindle (142) having an opening (158) extending between upper and lower ends. A rotatable platform (134) is mounted to the upper end of the spindle, the platform including a top surface (136), a bottom surface (138) and a central opening (140) in substantial alignment with the spindle opening (158). The deposition chamber also includes a substantially porous wafer carrier (124) having wafer-receiving cavities (128) positioned over the top surface (136) of platform (134) and having a hollow space (130) in substantial alignment with central opening (140) of the platform (134). Spindle opening (158) is desirably connected to a vacuum pump so that the pressure level within hollow space (130) of the water carrier (124) is less than the pressure level within deposition chamber, thereby creating suction within the wafer-receiving cavities (128) for maintaining the wafers (122) in a substantially flat orientation.

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APPARATUS FOR GROWING EPITAXIAL LAYERS ON WAFERS

Technical Field

The present invention relates to making semiconductor components and more particularly relates to devices for growing epitaxial layers on substrates, such as wafers.

Background Art

Semiconductor wafers are frequently manufactured by placing wafer substrates within a reaction chamber of a chemical vapor deposition (CVD) reactor and then growing one or more epitaxial layers on the wafers. During this process, wafers are placed inside the CVD reactor and reactant chemicals in gaseous form are introduced over the wafers in controlled quantities and at controlled rates for growing epitaxial layers on the wafers.

CVD reactors have various designs, including horizontal reactors in which wafers are mounted at an angle to the inflowing reactant gases; horizontal reactors with planetary rotation in which the reactant gases pass across the wafers; barrel reactors; and vertical reactors in which wafers are rotated at a relatively high speed within the reaction chamber as reactant gases are injected downwardly onto the wafers.

The reactant chemicals, commonly referred to as precursors, are typically introduced into the reaction chamber by placing the reactant chemicals in a device known as a bubbler and then passing a carrier gas through the bubbler. The carrier gas picks up molecules of the reactant chemicals to provide a reactant gas which is then fed into the reaction chamber of the CVD reactor using a mass flow controller.

The conditions under which the reactant gases are introduced into the reaction chamber have a dramatic effect upon the characteristics of the epitaxial layers grown on the wafers. These conditions, which may be modified to optimize the nature of the epitaxial layers grown on the wafers, typically include material viscosity, density, vapor pressure, the flow path of the reactant gases, chemical activity and temperature. For example, the flow path of the reactant gases may be altered by changing the design of the flow flange used to introduce reactant gases into reaction chambers. In many instances, the epitaxial layers grown on the substrates are studied to determine the optimum flow path for growing a particular type of layer.

When depositing epitaxial layers on wafers, the wafers are typically placed on a wafer carrier within a reaction chamber, which, in turn, may be placed upon a rotatable susceptor. In these reactors, the growth of uniform epitaxial layers is attained by rapidly rotating the wafer carrier and susceptor on which the wafers are mounted. The thickness, composition and quality of the deposited layers determine the characteristics of the resulting semiconductor devices. Accordingly, the deposition process must be capable of depositing films of uniform composition and thickness on the front face of each wafer. The requirements for uniformity have become progressively more stringent with the use of larger wafers and with the use of apparatus which deposit coatings on several wafers simultaneously.

In deposition processes using conventional wafer carriers, the surface temperature of the wafers is usually cooler than the surface temperature of the wafer carrier as a result of the thermal resistance created by the interface between the wafers and the wafer carrier and the different emissivities of the materials from which the wafer carrier and the wafer are made. Unfortunately, this temperature difference diminishes the quality of the resultant semiconductor wafers. For example, the higher temperature of the wafer carrier surface results in a nonuniform temperature on the surface of the wafers, particularly along their outer periphery, such that the layer(s) deposited along peripheral portions of wafers ordinarily are of poor quality and must be discarded.

In the typical prior art device shown in FIG. 1A, a wafer 10 is mounted atop a wafer carrier 12. In turn, the wafer carrier 12 is mounted on a susceptor 14 that is attached atop a rotatable support spindle 16. The wafer(s) 10, wafer carrier 12, and the upper end of susceptor 14 are generally located within an enclosed reactor chamber. A heating assembly 18 may be arranged below susceptor 14 for heating the susceptor, the wafer carrier 12 and wafer(s) 10 mounted thereon. Spindle 16 preferably rotates so as to enhance the uniformity of reactant gases flowing over the wafers 10. Rotating spindle 16 generally enhances the uniformity of reactant gases flowing over wafers 10 as well as temperature uniformity across the wafers 10.

Wafer carrier 12 includes circular-shaped pockets 20 on their upper surfaces 22 for holding wafers 10 in place as wafer carrier 12 is rotated during the deposition process. Typically, the circular pockets 20 have a diameter that is about 0.020" larger than the

diameter of the wafer(s) 10 and a depth that is about 0.002" deeper than the thickness of the wafers. These wafer carriers 12 also typically include an annular flange 24 which is used for lifting and transporting wafer carrier 12 into and out of the reaction chamber. On its bottom surface, wafer carrier 12 may include an annular wall 26 for locating and holding wafer carrier 12 on susceptor 14 as the wafer carrier is rotated during the deposition process.

Referring to Fig. 1B, during the deposition process, wafers 10 are heated by heating assembly 18. As a result, earlier deposited epitaxial layers generally have a higher temperature than later deposited epitaxial layers. This frequently results in the peripheral edges 28 of each wafer 10 curling up and away from wafer carrier 12, as shown in FIG. 1B. As a result, the peripheral edges 28 of wafer(s) 10 are no longer in contact with wafer carrier 12 and are no longer being heated to the same level as interior portions of the wafer. Although the present invention is not limited by any particular theory of operation, it is believed that the curling is due to the earlier deposited epitaxial layers being at a higher temperature than the later deposited epitaxial layers. Moreover, there is uneven heating of the wafers because the interior portions of the wafers are being heated while the curled outer portions of the wafers are further away from the heating assembly. As a result, the epitaxial layers are not uniform across the wafers and the curled portions of the wafers 10 must be discarded. This is because, *inter alia*, semiconductor devices taken from the curled portions of the wafer will have different operating characteristics than semiconductor devices taken from interior regions of the wafers.

Thus, there is a need for an apparatus that may deposit more uniform epitaxial layers atop the entire surface of each wafer. More particularly, there exists the need for a wafer carrier that will maintain the wafers substantially flat during the epitaxial layer forming process, thereby preventing the edges of the wafers from curling.

Summary of the Invention

An apparatus for growing epitaxial layers on substrates, such as wafers used to make semiconductor devices, includes a rotatable spindle having an upper end disposed inside a reaction chamber, a lower end disposed outside the reaction chamber and an opening extending between the upper and lower ends of the spindle. The apparatus includes a rotatable platform mounted to the upper end of the spindle. In certain

embodiments, the rotatable platform is preferably a susceptor made of a non-porous material. The upper end of the spindle preferably includes an outwardly extending flange portion for enhancing the mounting engagement between the rotatable platform and the spindle. The platform includes a top surface, a bottom surface in contact with the upper end of the spindle and a central opening extending between the top and bottom surfaces of the platform. When the rotatable platform is mounted atop the spindle, the central opening of the rotatable platform is preferably in substantial alignment with the opening extending between the upper and lower ends of the spindle. In certain preferred embodiments, the apparatus includes a motor connected to the rotatable spindle for selectively rotating the spindle and the platform mounted thereto. One or more vacuum rotating feedthroughs may be provided in sealing engagement with the spindle and/or the reaction chamber for providing a vacuum seal between the spindle and the reaction chamber and around the spindle.

The apparatus also desirably includes a substantially porous wafer carrier positioned over the top surface of the platform. The substantially porous wafer carrier preferably has a top surface including one or more cavities for receiving one or more wafers therein. Each cavity preferably has an outer diameter or perimeter that is greater than or equal to the outer diameter or perimeter of one of the wafers placed therein. In certain preferred embodiments, the diameter of each of the cavities formed in a top surface of the wafer carrier is approximately 1.0-1.25 times the diameter of each of the wafers positioned therein. The wafer carrier may also have a bottom surface that is in contact with the top surface of the platform. The bottom surface of the wafer carrier desirably has a hollow space formed therein. When the wafer carrier is positioned atop the platform, the hollow space in the wafer carrier is preferably in substantial alignment with the central opening of the platform. As a result, the hollow space in the wafer carrier is in substantial alignment with the central opening of the platform and the elongated opening extending through the rotatable spindle.

The substantially porous wafer carrier is preferably made of a material selected from the group consisting of graphite, SiC and molybdenum and preferably has a porosity of approximately of 7-14%. The wafer carrier may include one or more channels in communication with the hollow space. The one or more channels preferably extend

outwardly from the hollow space and may pass under the one or more of the cavities formed in the top surface of the wafer carrier. In certain preferred embodiments, the channels extend along the bottom surface of the wafer carrier and below the cavities of the wafer carrier. The wafer carrier may also include a sealing arrangement, such as a sealing ring, provided adjacent the outer perimeter thereof for isolating the hollow space of the wafer from the reactant gases within the deposition chamber. The sealing arrangement may include an outer flange portion of the wafer carrier that extends beyond an outer perimeter of the platform when the wafer carrier is positioned atop the platform. In certain embodiments, the top surface of the wafer carrier that surrounds the cavities may be covered with a non-porous coating or layer. As will be explained in more detail below, when wafers are placed in the cavities of the wafer carrier and a vacuum is drawn through the substantially porous wafer carrier, the non-porous layer will enhance the level of suction at the cavities, thereby improving the performance of the wafer carrier in maintaining the wafers substantially flat.

The deposition chamber may also include a pump in communication with the spindle opening that generates a vacuum or suction within the elongated opening extending through the spindle. Upon generating the area of low pressure within the spindle opening, a vacuum or low-pressure area of equal force is generated within both the central opening of the rotatable platform and the hollow space of the wafer carrier. The vacuum may extend from the hollow space to the one or more channels extending through the wafer carrier. When wafers are positioned within the cavities of the wafer carrier and one or more reactant gases are introduced into the reaction chamber, the vacuum or suction within the hollow space is less than the pressure level within the reaction chamber. As a result, suction develops in the cavities at an interface between the wafer and the wafer carrier. Such suction prevents the peripheral edges of the wafers from curling or pulling away from the wafer carrier as the epitaxial layers are deposited, as occurs in prior art deposition chambers (e.g., the prior art embodiment shown in Fig. 1A). As a result, uniform epitaxial layers are formed across the entire surface of the wafer, thereby providing reliable semiconductor devices that may be harvested from the peripheral regions of the wafers.

In accordance with other preferred embodiments of the present invention, an apparatus for supporting a wafer in a reaction chamber of a CVD reactor includes a rotatable spindle having an upper end disposed inside the reaction chamber and a lower end disposed outside the reaction chamber, the spindle including an opening extending between the upper and lower ends. The apparatus also includes a rotatable platform mounted atop the upper end of the spindle, the platform including a top surface, a bottom surface in contact with the upper end of the spindle and a central opening extending between the top and bottom surfaces of the platform, the central opening being in substantial alignment with the spindle opening. The apparatus may also include a substantially porous wafer carrier positioned over the top surface of the platform. The wafer carrier desirably includes a bottom surface having a hollow space in substantial alignment with the central opening of the platform and being in fluid communication with the spindle opening. The spindle opening is connected to a source of low pressure so that the pressure level within the hollow space of the wafer carrier is less than the pressure level above the wafers positioned on the wafer carrier. As a result, any wafers positioned atop the wafer carrier will be suctioned toward the wafer carrier and the edges of the wafers will not curl up, as occurs in prior art devices.

In still other preferred embodiments of the present invention, a method of growing epitaxial layers atop a wafer includes providing a reaction chamber having a rotatable, substantially porous wafer carrier therein, maintaining a first pressure level within the reaction chamber, placing a wafer atop the substantially porous wafer carrier, and after the placing step, drawing a vacuum through the substantially porous wafer carrier so that an interface between the wafer and the wafer carrier has a second pressure level that is less than the first pressure level present within the reaction chamber.

In other embodiments, a substantially porous wafer carrier has a top surface, a bottom surface and a plurality of wafer-receiving cavities formed in the top surface for receiving wafers. In this embodiment, the top surface of the wafer carrier surrounding the wafer-receiving cavities is covered by a non-porous layer. Although the present invention is not limited by any particular theory of operation, it is believed that the non-porous layer improves the strength of a vacuum force that may be drawn within the cavities. In still other embodiments, the top surface of a substantially porous wafer carrier does not have

cavities, but has wafer-receiving areas defined by a non-porous layer formed atop the wafer carrier. The wafer receiving areas are not covered by the non-porous layer so that suction at the wafer-receiving areas holds the wafers atop the wafer carrier when g rowing epitaxial layers.

These and other preferred embodiments of the present invention will be described in more detail below.

Brief Description of the Drawings

FIG. 1A is a cross-sectional view of a prior art wafer carrier including wafers mounted atop the wafer carrier, a susceptor, a rotatable spindle used to support the susceptor, and a heating device for heating the susceptor.

FIG. 1B shows the prior art wafer carrier of FIG. 1A with epitaxial layers being grown atop the wafers.

FIG. 2 shows a cross-sectional view of a deposition chamber including a wafer carrier, a rotatable platform and a rotatable spindle, in accordance with certain preferred embodiments of the present invention.

FIG. 3A shows a top view of the wafer carrier of FIG. 2 taken along line IIIA-IIIA of FIG. 2.

FIG. 3B shows a bottom view of the wafer carrier of FIG. 3A.

FIG. 4 shows a fragmentary cross-sectional view of the deposition chamber of FIG. 2.

FIG. 5 shows a cross-sectional view of a wafer carrier having wafer-receiving cavities and a substantially non-porous top surface surrounding the wafer-receiving cavities, in accordance with certain preferred embodiments of the present invention.

Best Mode of Carrying Out Invention

Figure 2 shows an apparatus for growing epitaxial layers on wafers in accordance with certain preferred embodiments of the present invention. The apparatus includes a deposition chamber 100 comprising a side wall 102, and a top flange 104 including one or more openings 106 for introducing reactant chemicals, such as reactant gases, into an interior region 108 of deposition chamber 100. Deposition chamber 100 also includes a bottom-sealing flange 110. The deposition chamber 100 is preferably made of stainless steel with the top and bottom flanges 104 and 110 being sealingly engaged with sidewall

102. The reactant gases introduced through the opening 106 in top flange 104 are generally uniformly distributed by one or more showerheads 114. The reactant gases preferably interact with one another inside deposition chamber 100 to form epitaxial layers upon wafers, as will be described in more detail below. After the reactant gases interact with one another and are deposited atop wafers, the waste material is removed through an exhaust 116 extending through bottom-sealing flange 110. In certain preferred embodiments, the waste reactant gases are removed through exhaust opening 116 using pump 118. The pressure level within the interior region 108 of deposition chamber 100 is regulated by throttle valve 120.

In order to grow epitaxial layers upon wafers, such wafers 122 are preferably positioned within deposition chamber 100 and atop wafer carrier 124. Wafer carrier 124 has a top surface 126, a bottom surface 128, and one or more wafer-receiving cavities 128 adapted to receive one or more wafers 122 therein. Each wafer-receiving cavity 128 preferably has a diameter that is greater than or equal to the outer diameter of the wafer 122 stored therein. Wafer carrier 124 also preferably includes a hollow space 130 formed in the bottom surface 128 of wafer carrier 124. The hollow space 130 may be centrally located on the wafer carrier 124. The wafer carrier 124 is preferably made of a substantially porous material such as graphite, SiC, molybdenum or other well-known materials typically used for wafer carriers. In certain preferred embodiments, the porosity of wafer carrier 124 is approximately between 7-14%.

Wafer carrier 124 also includes outer flanges 132 that define the outer perimeter of wafer carrier 124. Wafer carrier 124 is adapted to be positioned atop a rotatable platform or susceptor. Susceptor 134 has a top surface 136 and bottom surface 138 remote therefrom. Susceptor 134 also includes a central opening 140 extending between top and bottom surfaces 136, 138.

Susceptor 134 is connected to a rotatable spindle 142 having an upper end 144 disposed inside deposition chamber 100 and a lower end 146 located outside the deposition chamber. The uppermost end of spindle 142 desirably includes a flanged portion 148 mounted to the bottom surface 138 of susceptor 134. Spindle 142 may be rotated by a motor 150 through pulleys 152, 154 and belt 156. Spindle 142 preferably has an elongated opening 158 extending therethrough that is aligned with the central opening

140 extending through susceptor 134. When wafer carrier 124 is provided atop susceptor 134, the hollow space 130 at the bottom surface 128 thereof is preferably in substantial alignment with spindle opening 158 and susceptor opening 140. The outer flanges 132 hold wafer carrier 124 atop susceptor 134 as wafer carrier 124 and susceptor 134 rotate.

The lowermost end of spindle 142 is preferably connected to pump 118 for drawing a vacuum through spindle opening 158. Differential pressure controller 162 regulates the pressure within the interior region 108 of deposition chamber 100 and the pressure level within spindle opening 158, susceptor opening 140 and hollow space 130, so that the pressure level within hollow space 130 is always less than the pressure level within the interior region 108 of deposition chamber 100. In certain preferred embodiments, a vacuum seal is provided between deposition chamber 100 and spindle 142, or around spindle 142, such as by using one or more vacuum rotating feedthroughs 160 and 164. Well known vacuum rotating feedthroughs are manufactured by Ferrofluidic Corporation, Advanced Fluid Systems and Rigaku.

As mentioned above, wafer carrier 124 preferably includes hollow space 130 formed at the bottom surface 128 of wafer carrier 124. As pump 118 is activated, a vacuum is created within spindle opening 158, susceptor opening 140 and hollow space 130. The wafer carrier includes one or more channels 135 in communication with hollow space 130 so that the low pressure or vacuum within hollow space 130 may pass throughout the entire area of the substantially porous wafer carrier. As a result, the pressure level at the interface of the wafers 122 and the wafer carrier (i.e., within the cavities 128) is less than the pressure level within the interior region 108 of reaction chamber 100. As used herein, the terminology "interface of the wafers 122 and wafer carrier" means the areas of the wafer carrier in direct contact with the wafers placed on the carrier. The low pressure at the interface suctions the wafers 122 to cavities 128, thereby preventing the peripheral edges of the wafers 122 from curling up, as occurs with the prior art device shown in Figure 1B. Although the present invention is not limited by any particular theory of operation, it is believed that maintaining the wafers 122 substantially flat during deposition of reactant gases thereupon will result in the formation of semiconductor wafers having uniform epitaxial layers across the entire area of the wafers.

As a result, the semiconductor devices formed at the edges of the wafer may be used, and not discarded as occurs with prior art processes.

In certain preferred embodiments, wafer carrier 124 has a flange region 132 that aligns wafer carrier 124 atop susceptor 134 and prevents wafer carrier 124 from falling off susceptor 134 during rotation of susceptor. Flange region may also provide a seal between the wafer carrier 124 and susceptor 134 for isolating the relatively higher pressure gas within the interior region 108 of deposition chamber 100 from the relatively lower pressure gas in hollow space 130 and the channels 135 of wafer carrier 124.

FIG. 3A shows a top view of wafer carrier 124 of Figure 2, in accordance with certain preferred embodiments of the present invention. Wafer carrier 124 includes top surface 126 having a plurality of wafer-receiving cavities 128 formed thereon. Wafer carrier 124 includes a peripheral flange 132 that extends around the outer perimeter thereof. As mentioned above, peripheral flange 132 preferably provides an alignment guide for positioning wafer carrier 124 atop susceptor 134. The peripheral flange 132 may also provide a sealing function for effectively isolating the relatively higher pressure gas within the interior region 108 of deposition chamber 100 from the relatively lower pressure within hollow space 130 of wafer carrier 124.

FIG. 3B shows a bottom view of wafer carrier 124 including hollow space 130 and channels 135 that extend outwardly from hollow space 135 and around cavity support regions 168 of wafer carrier 124. The channels 135 preferably distribute the vacuum generated by pump 118 in a more uniform pattern throughout substantially porous wafer carrier 124. In certain preferred embodiments, cavity support regions 168 are in substantial alignment the wafer-receiving cavities 128. The cavity support regions 168 may have diameters that are approximately 1-1.5 times the diameter of the wafer-receiving cavities 128. Although the present invention is not limited by any particular theory of operation, it is believed that the cavity support regions 168 enhance the structural stability of wafer carrier 124 so as to prevent the wafer carrier 124 from warping, bending or buckling when a vacuum is drawn through wafer carrier 124.

FIG. 4 shows an expanded view of wafer carrier 124 positioned atop susceptor 134 during an epitaxial layer forming process. After one or more wafers 122 are positioned within cavities 128, reactant gases 170 are deposited atop wafers 122. Initially, spindle

142 is rotated by motor 150 (not shown) which, in turn, rotates susceptor 134 mounted to upper end 144 of spindle 142 and wafer carrier 124. Reactant gases 170 are then introduced into the interior region 108 of deposition chamber 100. Pump 118 (FIG. 2) draws a vacuum 172 through spindle opening 158. As the vacuum is drawn through spindle opening 158 and susceptor opening 140, a vacuum of similar magnitude is formed in hollow space 130 of wafer carrier 124. Due to the substantial porosity of the wafer carrier 124, suction 175 is generated at an interface 174 between the cavities 128 and wafers 122. The suction 175 pulls the edges 176 of the wafers 122 into the cavities 128 so as to prevent the peripheral edges 176 of the wafers 122 from curling during formation of the epitaxial layers. As a result, semiconductor wafers having uniform layers and/or consistent properties across the entire surface thereof may be formed.

FIG. 5 shows a wafer carrier 224 for receiving wafers 222, in accordance with other preferred embodiments of the present invention. Wafer carrier 224 has top surface 226 and bottom surface 228 remote therefrom. Wafer carrier 224 has one or more wafer-receiving cavities 229 formed therein. Each cavity 229 is sized and shaped to receive a wafer 222 so that epitaxial layers may be grown on the wafer. Each cavity 229 defines an interface 274 that confronts an underside of a wafer 222. The top surface 226 of wafer carrier 224 surrounding the cavities 229 is covered by a non-porous layer 280. As a vacuum is drawn through hollow space 230, the non-porous layer 280 causes the vacuum force to be concentrated at the wafer/carrier interface 274, thereby enhancing the ability of the assembly to maintain the wafers 222 in a substantially flat position as epitaxial layers are grown. In still other embodiments, the top surface of wafer carrier is substantially flat and has wafer-receiving areas defined by a non-porous coating that is formed over the top surface and that surrounds the wafer-receiving areas. When porous wafer carrier, such vacuum force is concentrated at the wafer-receiving areas of the carrier (i.e., the areas at the top surface of the wafer not covered by a non-porous coating).

As these and other variations and combinations of the features discussed above can be employed, the foregoing description of preferred embodiments should be taken by way of illustration rather than as limiting the claims.

Industrial Applicability

The invention has applicability in the semiconductor industry.

Claims:

1. An apparatus for growing epitaxial layers on wafers comprising:

a rotatable spindle having an upper end disposed inside a reaction chamber, a lower end disposed outside said reaction chamber, and an opening extending between the upper and lower ends of said spindle;

a rotatable platform mounted to the upper end of said spindle, said platform including a top surface, a bottom surface in contact with the upper end of said spindle and a central opening extending between the top and bottom surfaces of said platform, said central opening being in substantial alignment with the spindle opening;

a substantially porous wafer carrier positioned over the top surface of said platform and having a bottom surface in contact with the top surface of said platform, the bottom surface of said wafer carrier having a hollow space that is in substantial alignment with the central opening of said platform, wherein the lower end of said spindle is connected to a source of low pressure so that the pressure level within the hollow space of said wafer carrier is less than the pressure level within said reaction chamber.

2. The apparatus as claimed in claim 1, wherein said substantially porous wafer carrier is made of a material selected from the group consisting of graphite, SiC, and molybdenum.

3. The apparatus as claimed in claim 1, wherein said substantially porous wafer carrier has a porosity of approximately 7-14%.

4. The apparatus as claimed in claim 1, wherein said rotatable platform is a susceptor made of a non-porous material.

5. The apparatus as claimed in claim 1, further comprising a motor connected to said rotatable spindle for selectively rotating said spindle and said platform.

6. The apparatus as claimed in claim 1, further comprising a vacuum rotating feedthrough in sealing engagement with said spindle for providing a vacuum seal between said spindle and said chamber.

7. The apparatus as claimed in claim 1, wherein the opening extending through said spindle, the central opening in said rotatable platform, and the hollow space at the bottom surface of said wafer carrier are is substantial alignment with one another.

8. The apparatus as claimed in claim 7, wherein the lower end of said spindle is connected to a vacuum pump so that the pressure level within the hollow space of said wafer carrier is less than the pressure level within said reaction chamber.

9. The apparatus as claimed in claim 1, wherein said wafer carrier has a top surface including one or more cavities for receiving one or more wafers.

10. The apparatus as claimed in claim 9, wherein the top surface of said wafer carrier surrounding the one or more wafer-receiving cavities is covered by a non-porous layer.

11. The apparatus as claimed in claim 9, wherein each said cavity has a diameter that greater than or equal to the diameter of one of said wafers.

12. The apparatus as claimed in claim 11, wherein the diameter of each said cavity is approximately 1.0-1.25 the diameter of each said wafer.

13. The apparatus as claimed in claim 1, wherein said wafer carrier includes one or more channels in communication with said hollow space and extending outwardly from said hollow space.

14. The apparatus as claimed in claim 9, wherein said wafer carrier includes one or more channels in communication with said hollow space and extending outwardly from said hollow space toward an outer perimeter of said wafer carrier.

15. The apparatus as claimed in claim 14, wherein at least one of said channels passes below at least one of said cavities of said wafer carrier.

16. The apparatus as claimed in claim 1, wherein said wafer carrier has an outer perimeter including a sealing arrangement for isolating the relatively lower pressure within the hollow space of said wafer carrier from the relatively higher pressure within said deposition chamber.

17. The apparatus as claimed in claim 13, wherein said sealing arrangement includes an outer flange portion of said wafer carrier that extends beyond an outer perimeter of said platform.

18. An apparatus for supporting a wafer in a deposition chamber comprising:

a rotatable spindle having an upper end disposed inside said deposition chamber and a lower end disposed outside said deposition chamber, said spindle including an opening extending between the upper and lower ends;

a rotatable platform mounted atop the upper end of said spindle, said platform including a top surface, a bottom surface in contact with the upper end of said spindle and a central opening extending between the top and bottom surfaces of said platform, said central opening being in substantial alignment with the spindle opening;

a substantially porous wafer carrier positioned over the top surface of said platform, said wafer carrier including a bottom surface having a hollow space in substantial alignment with the central opening of said platform and being in fluid communication with the spindle opening, wherein said spindle opening is connected to a source of low pressure so that the pressure level within said hollow space of said wafer carrier is less than the pressure level around said wafer carrier.

19. The apparatus as claimed in claim 18, wherein said wafer carrier has a top surface including one or more cavities for receiving one or more of said wafers.

20. The apparatus as claimed in claim 19, wherein said cavities at the top surface of said wafer carrier have diameters that are greater than or equal to the diameters of said wafers.

21. The apparatus as claimed in claim 19, wherein said wafer carrier includes one or more channels in fluid communication with said hollow space and extending outwardly from said hollow space.

22. The apparatus as claimed in claim 21, wherein at least one of said channels passes below at least one of said cavities of said wafer carrier.

23. A method of growing epitaxial layers atop a wafer comprising:

providing a deposition chamber having a rotatable, substantially porous wafer carrier therein;

maintaining a first pressure level within said deposition chamber;

placing a wafer atop said substantially porous wafer carrier;

after the placing step, drawing a vacuum through said substantially porous wafer carrier so that an interface between said wafer and said wafer carrier has a second pressure level that is less than the first pressure level within said deposition chamber, wherein said wafer is maintained in a substantially flat orientation.

24. The method as claimed in claim 23, further comprising rotating said substantially porous wafer carrier.

25. The method as claimed in claim 24, further comprising introducing one or more reactants into said deposition chamber during the drawing a vacuum step.

26. The method as claimed in claim 23, further comprising heating said wafer carrier.

27. The method as claimed in claim 23, wherein said substantially porous wafer carrier is made of a material selected from the group consisting of graphite, SiC, and molybdenum.

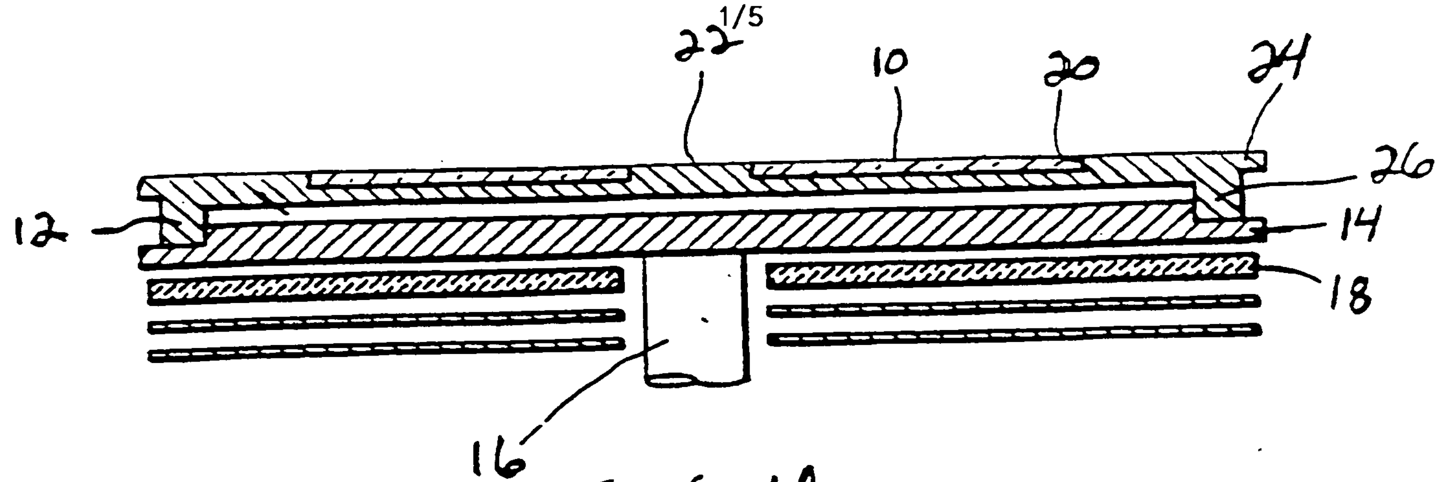

FIG. 1A

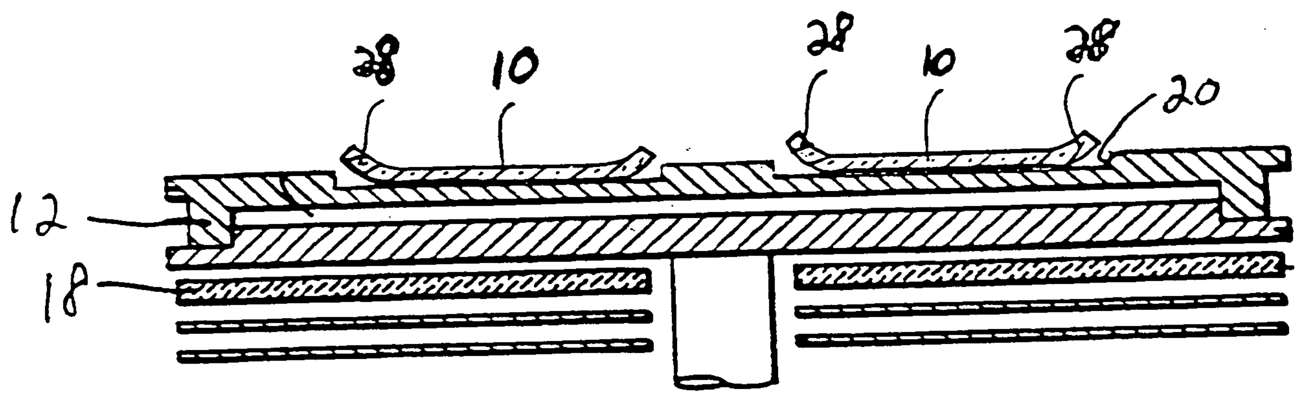

FIG. 1B

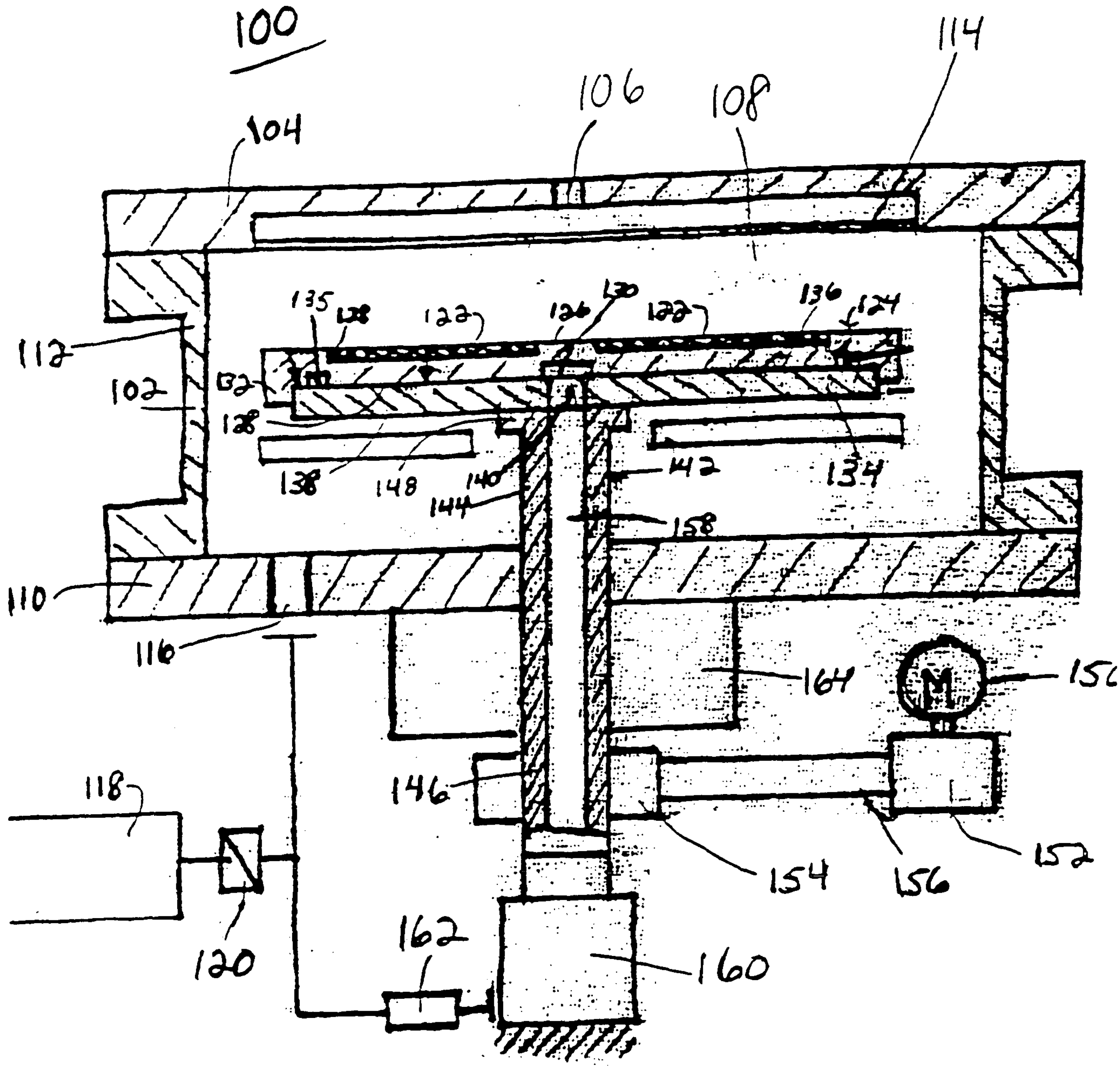
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FIG. 2

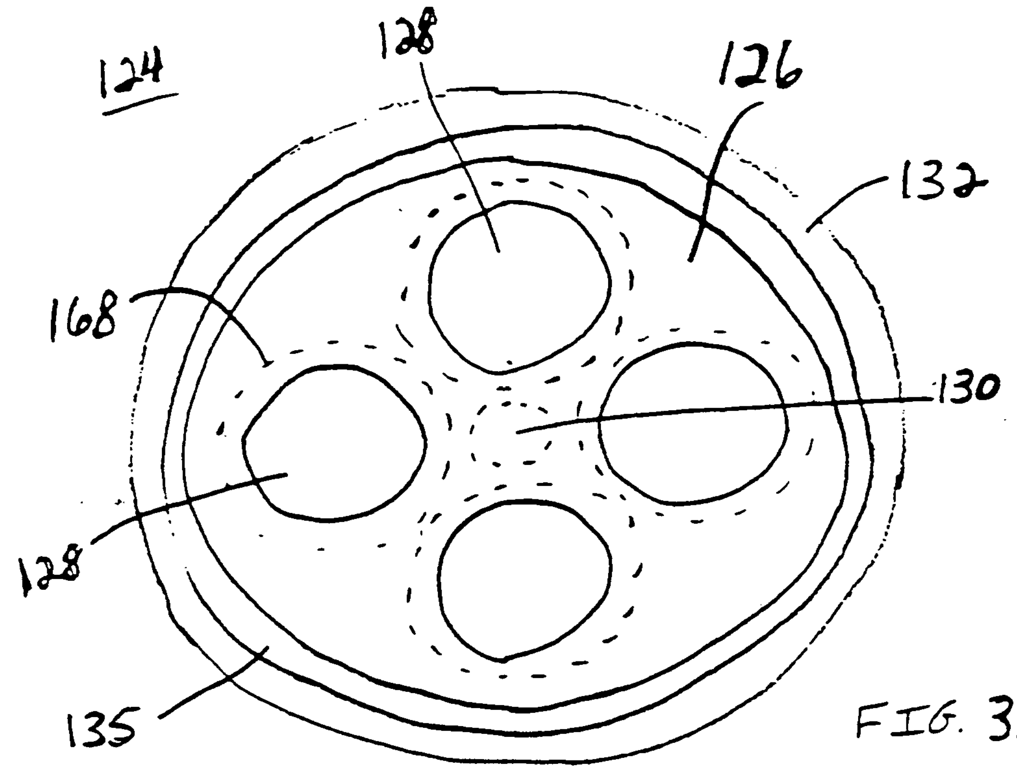

FIG. 3A

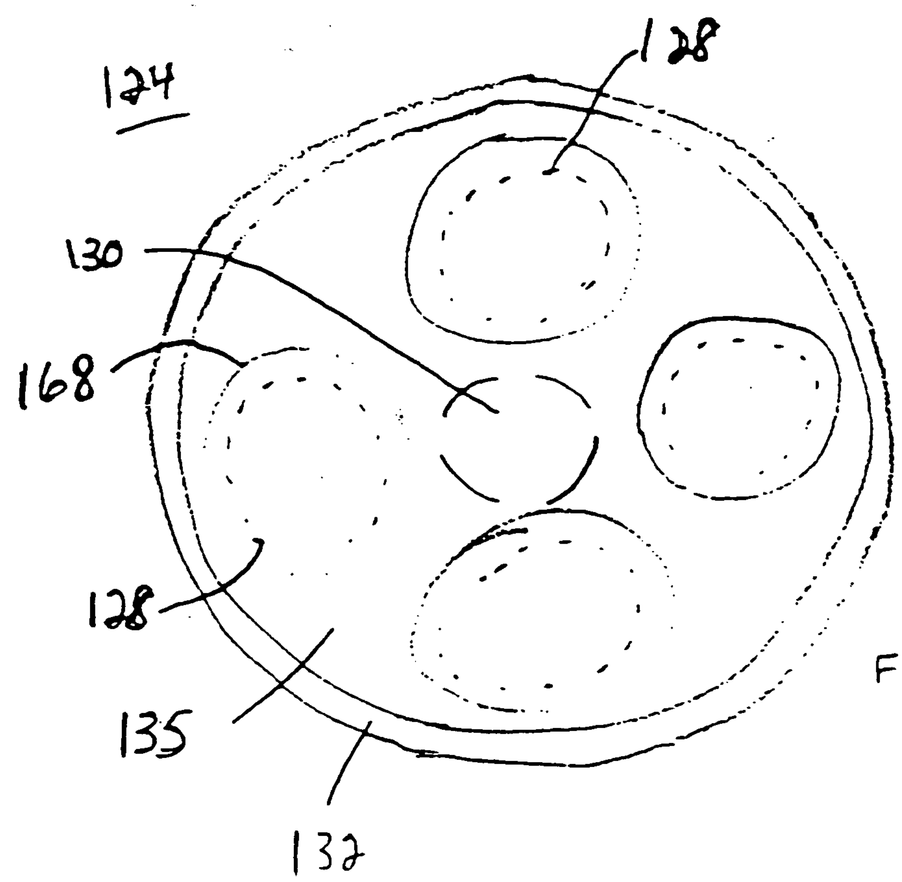

FIG. 3B

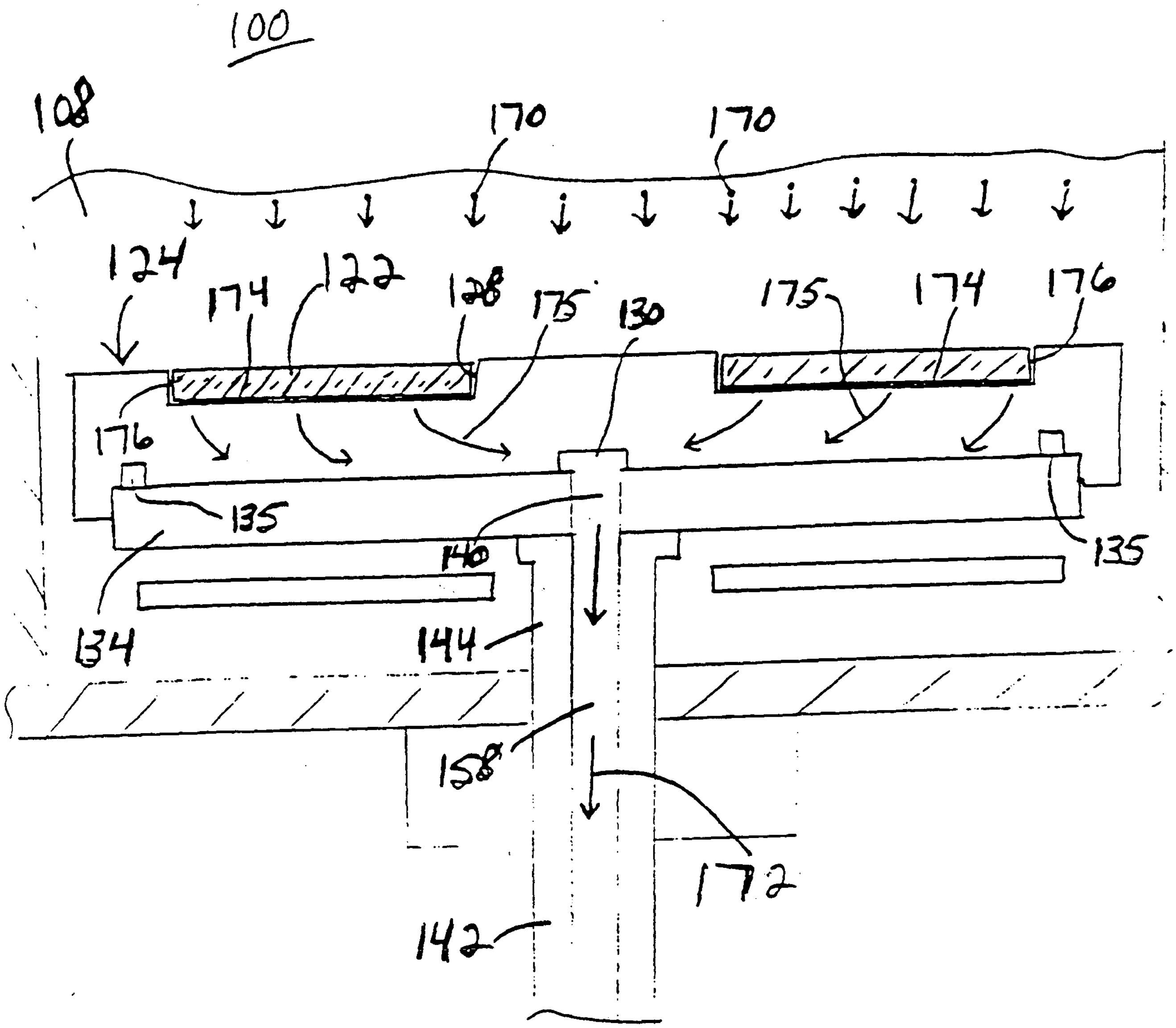
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FIG. 4

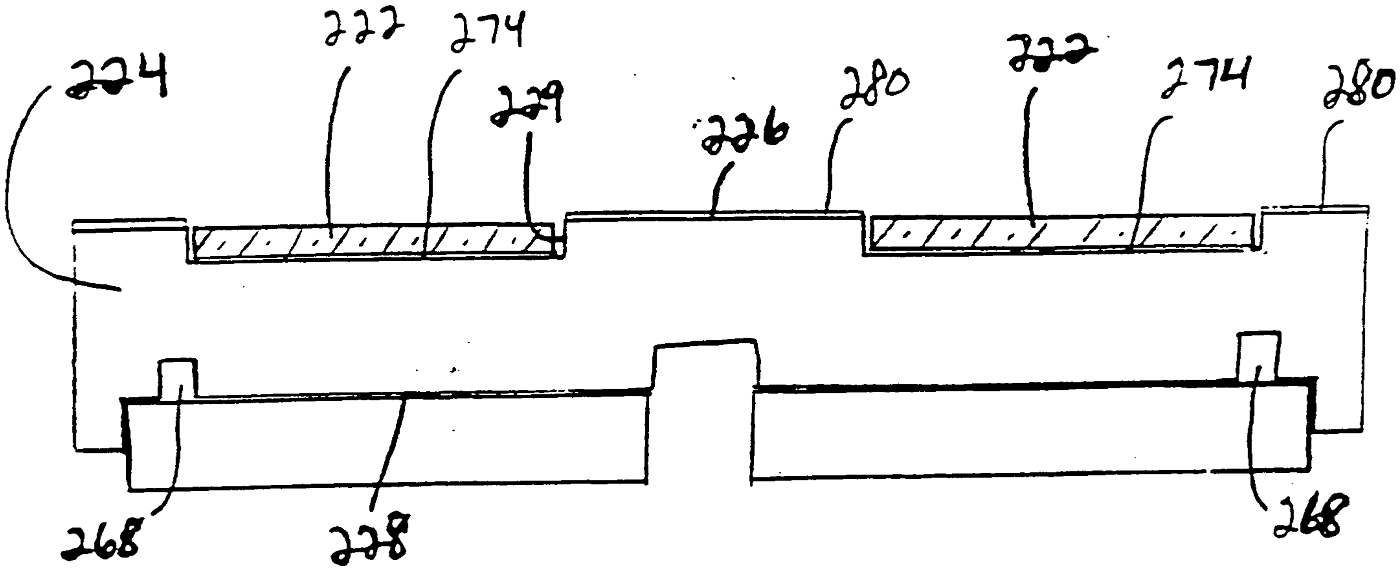

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/19879

A. CLASSIFICATION OF SUBJECT MATTER
IPC(7) :C30B 23/02, 25/12; C23C 16/458
US CL :117/84, 98, 101, 200; 118/730, 732
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
U.S. : 117/84, 98, 101, 200; 118/730, 732

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EAST search of USPAT, EPO, JPO and IBM TDB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,370,739 A (FOSTER et al.) 06 December 1994, col. 10 lines 24-27; col. 15 lines 12-17 and 25-30; and col. 17 lines 15-21.	1-27

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search	Date of mailing of the international search report
25 SEPTEMBER 2000	20 NOV 2000

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